Cyber S&T Priority Steering Council Research Roadmap

for the

National Defense Industrial Association Disruptive Technologies Conference

8 November 2011

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Report Documentation Page

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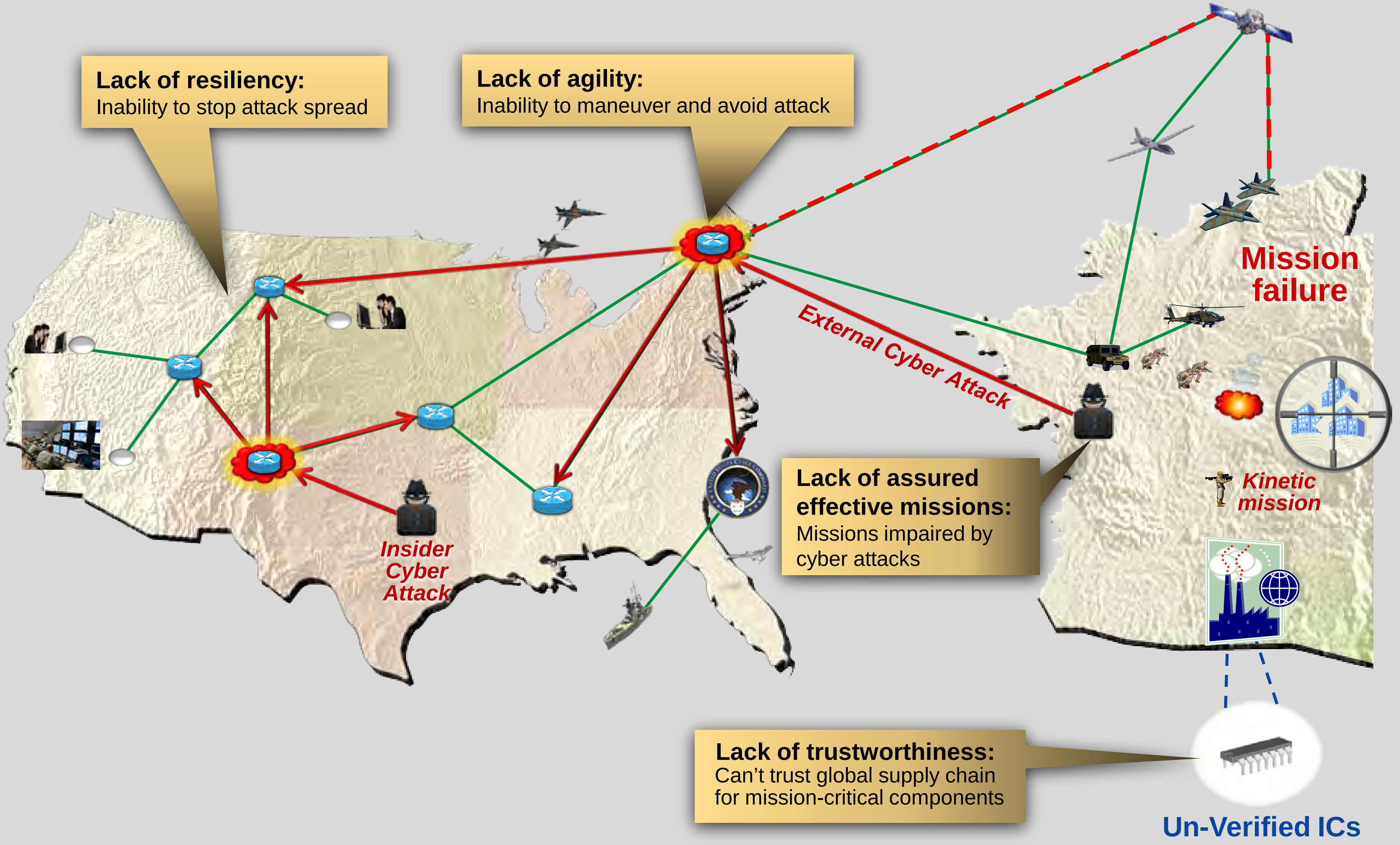
Problem Statement



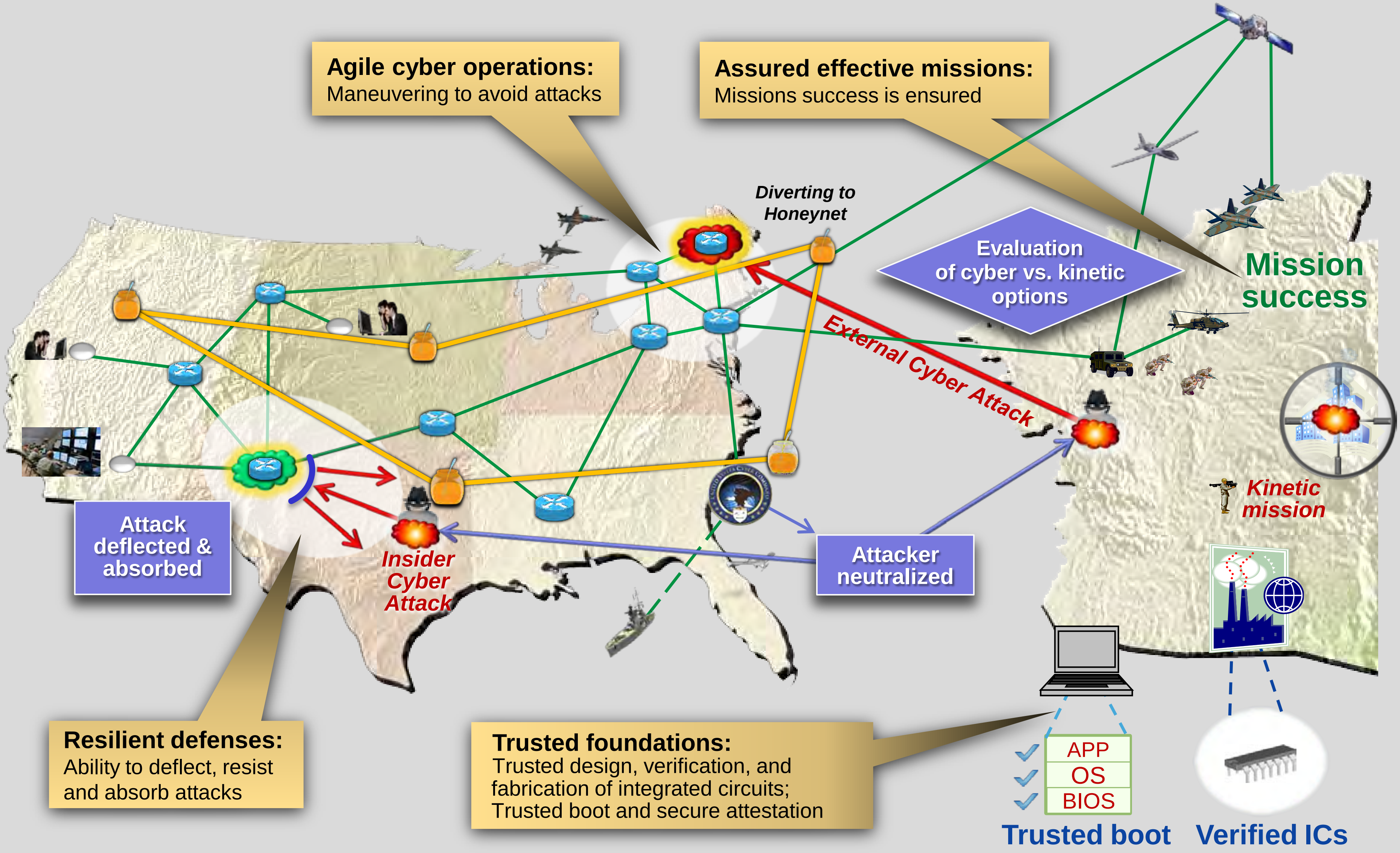
Lack of resiliency:
Inability to stop attack spread

Lack of agility:
Inability to maneuver and avoid attack

Lack of assured effective missions:
Missions impaired by cyber attacks

Lack of trustworthiness:
Can’t trust global supply chain for mission-critical components

Desired End State



Agile cyber operations:
Maneuvering to avoid attacks

Assured effective missions:
Missions success is ensured

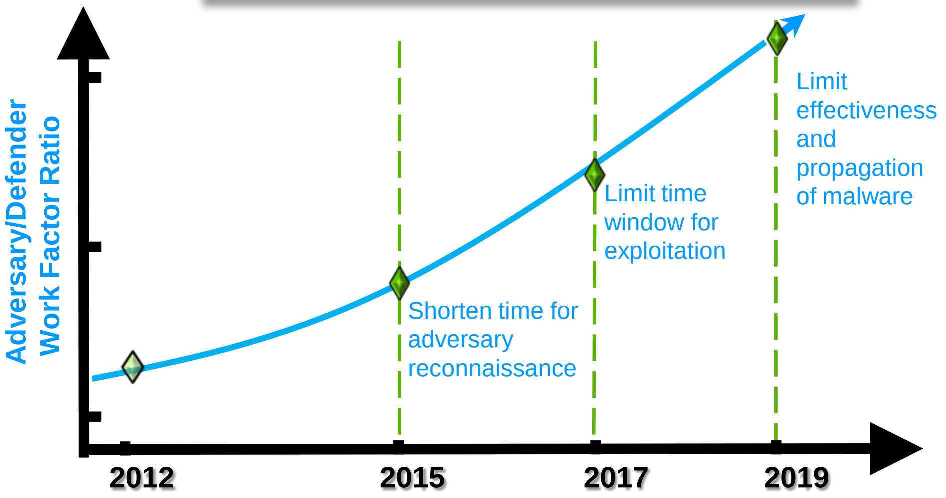
Resilient defenses:
Ability to deflect, resist and absorb attacks

Trusted foundations:
Trusted design, verification, and fabrication of integrated circuits;
Trusted boot and secure attestation

Key Parameter: Work Factor Ratio

- **Missions**
  - Kinetic, cyber, and combined missions will have a cyber dependency
- **Infrastructure**
  - Any element of the cyber infrastructure may be compromised and manipulated
  - DoD will continue to leverage commercial products and services we do not own or control
  - DoD infrastructure defies establishing an all-encompassing static perimeter

Challenge: Increase Adversary / Defender Relative Work Factor Over Time



Shorten time for adversary reconnaissance

Limit time window for exploitation

Limit effectiveness and propagation of malware

Perimeter is not well defined

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Four Major 10 Year Objectives

Assuring Effective Missions	Assess and control the cyber situation in mission context
Agile Operations	Dynamically reshape cyber systems as conditions/goals change, to escape harm

Resilient Infrastructure	Withstand cyber attacks, and sustain or recover critical functions
Trust	Establish known degree of assurance that devices, networks, and cyber-dependent functions perform as expected, despite attack or error

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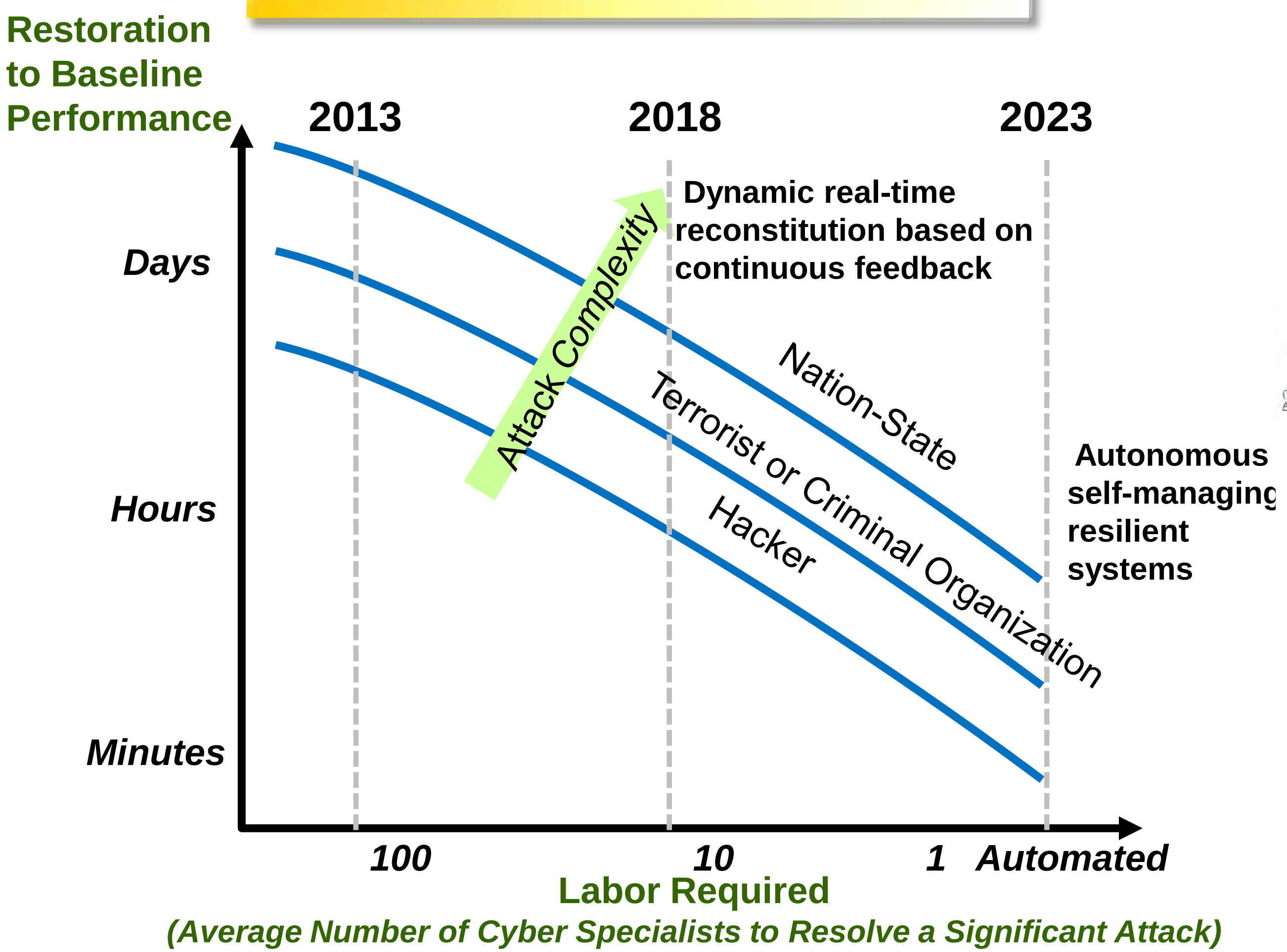
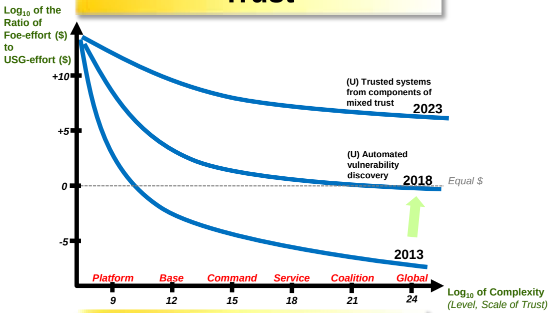
Metrics

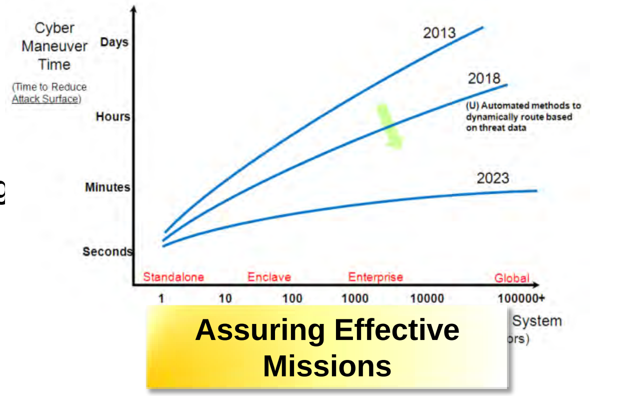
Resilient Infrastructure



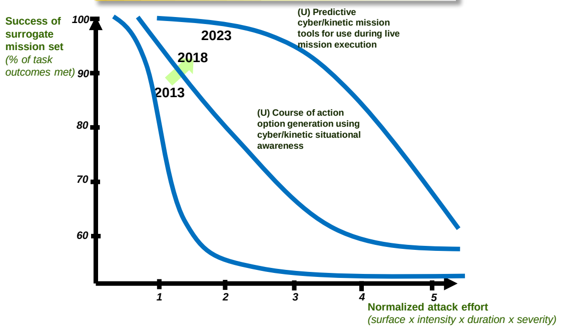
Trust



Operational Agility



Assuring Effective Missions



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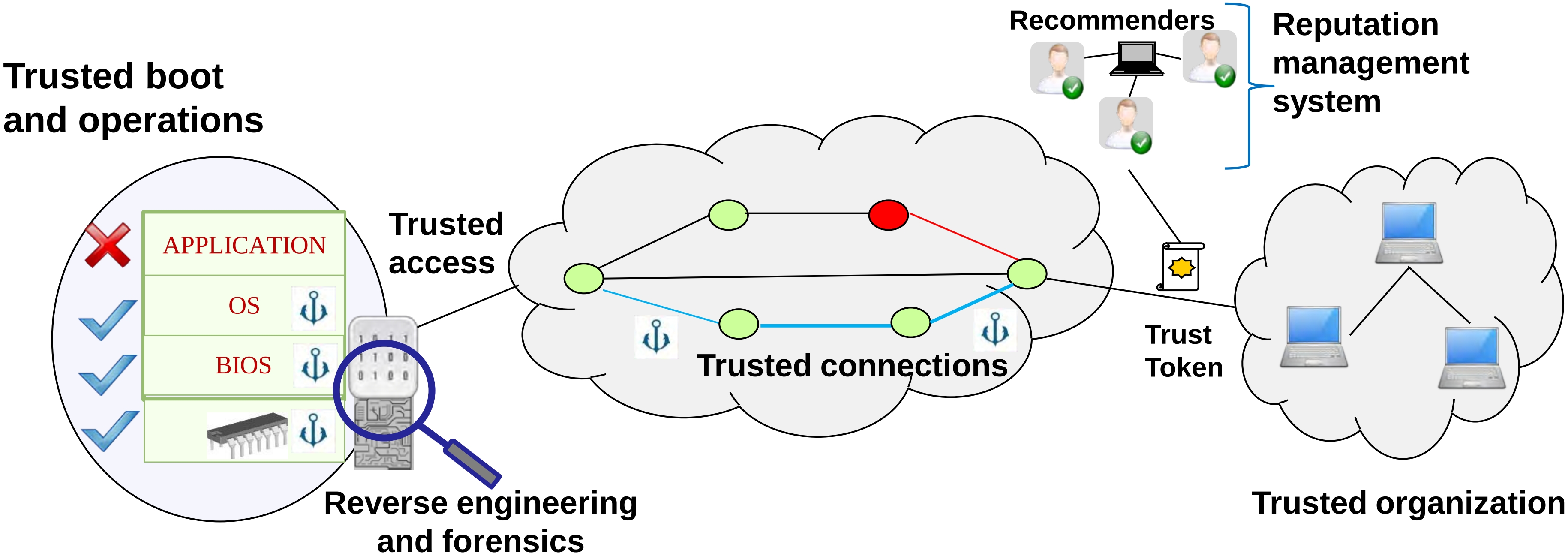
Trust

Technical Challenges and Research Opportunities



Trust Foundations

- Scalable reverse engineering and analysis
- Trust establishment, propagation, and maintenance techniques
- Measurement of trustworthiness
- Trustworthy architectures and trust composition tools

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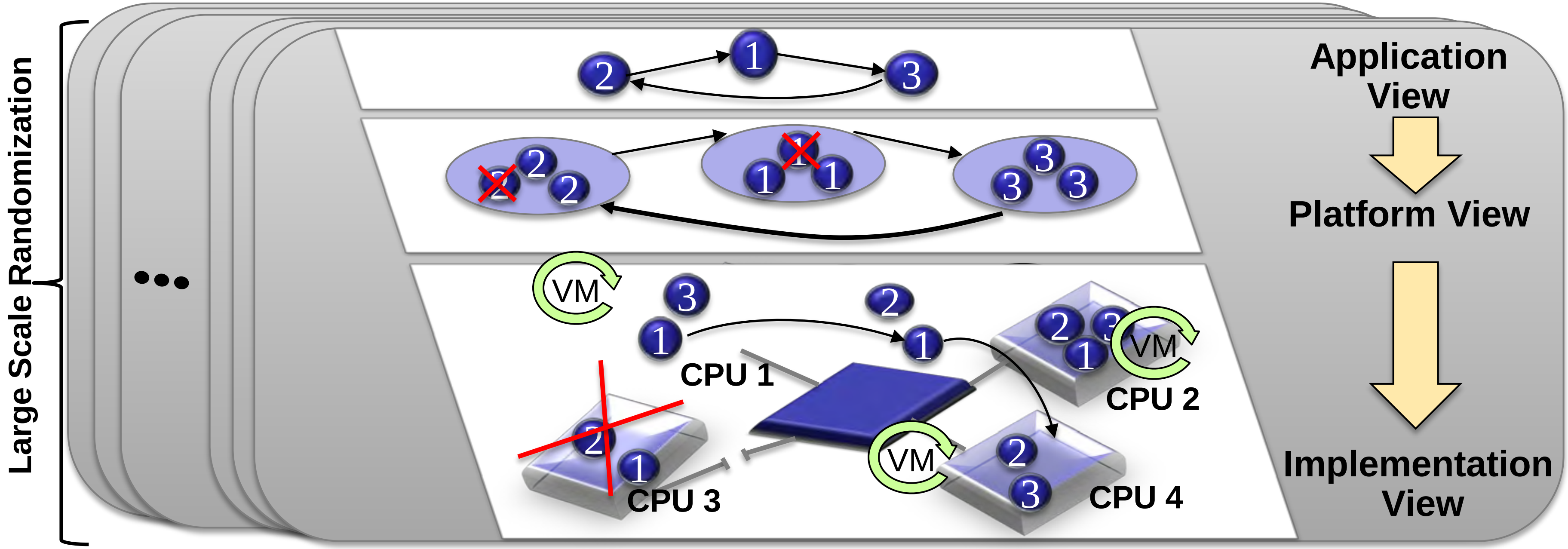
Resilient Infrastructure

Technical Challenges and Research Opportunities



Resilient Architectures

- Resiliency for operational systems
- Mechanisms to compose resilient systems from brittle components
- Integration of sensing, detection, response, and recovery mechanisms
- Secure modularization and virtualization of nodes and networks
- Resiliency-specific modeling and simulation

Resilient Algorithms and Protocols

- Code-level software resiliency
- Network overlays and virtualization
- Network management algorithms
- Mobile computing security

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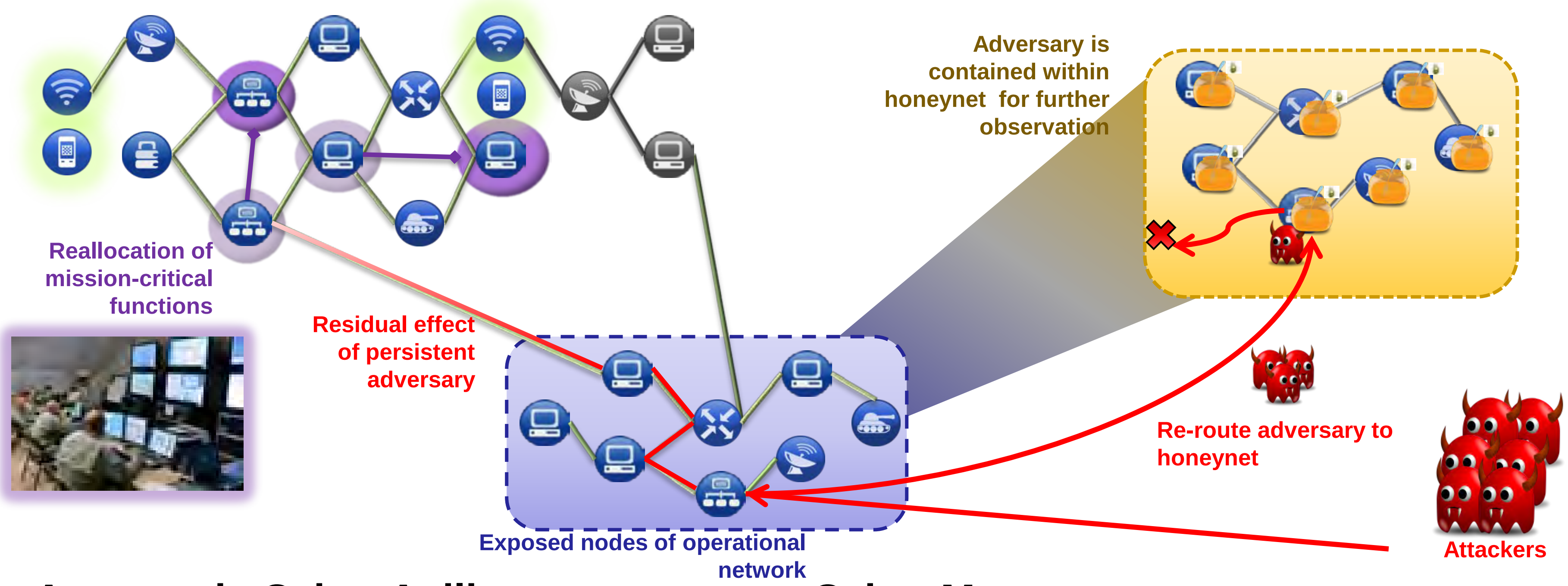
Agile Operations

Technical Challenges and Research Opportunities


Adversary is contained within honeynet for further observation
Reallocation of mission-critical functions
Residual effect of persistent adversary
Re-route adversary to honeynet
Exposed nodes of operational network
Attackers

Autonomic Cyber Agility

- Techniques for autonomous reprogramming, reconfiguration, and control of cyber components
- Machine intelligence and automated reasoning techniques for executing courses of action

Cyber Maneuver

- Distributed systems architectures and service application polymorphism
- Network composition based on graph theory
- Distributed collaboration and social network theory

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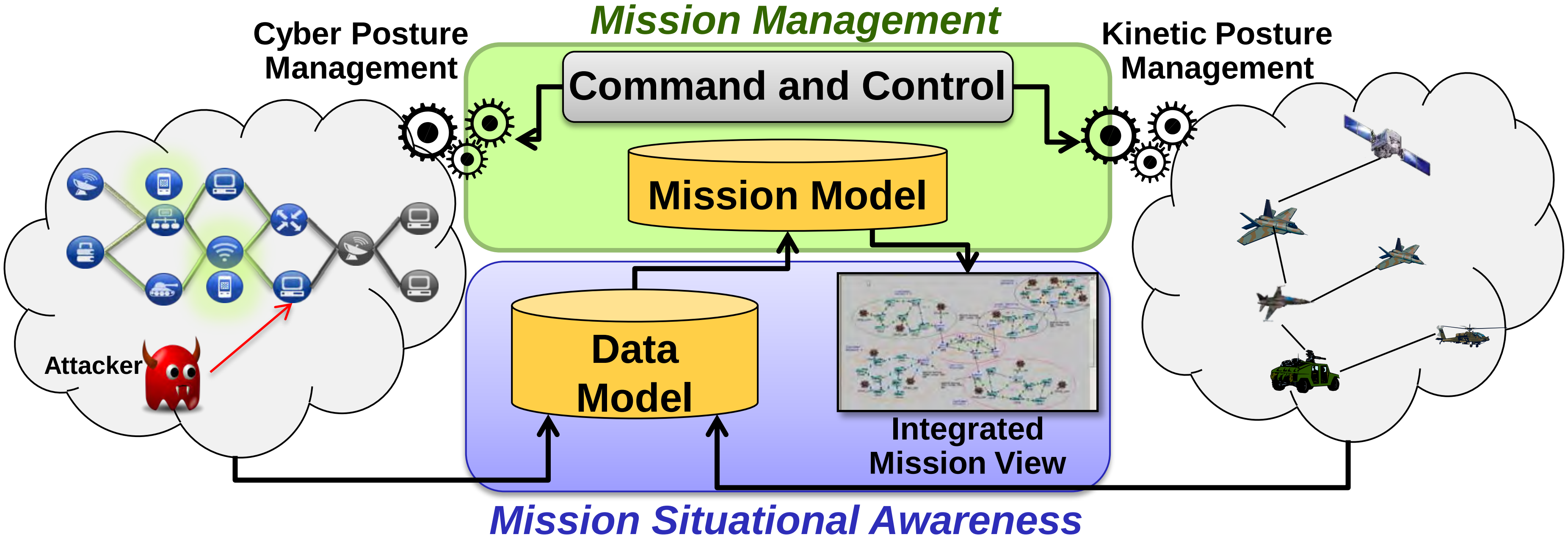
Assuring Effective Missions

Technical Challenges and Research Opportunities



Cyber Mission Control

- Techniques for mapping assets and describing dependencies between mission elements and cyber infrastructure
- Techniques for course of action development and analysis
- Cyber effects assessment

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Open Broad Agency Announcements

- **Army Research Office (ARO)**
  - Solicitation #:W911NF-07-R-0003-04; BAA for Basic and Applied Research, Section 5.3
- **Army Research Laboratory (ARL)**
  - Solicitation #:W911NF-07-R-0001-05; BAA for Basic and Applied Research, Section 1
- **Communications and Electronics Research, Development, and Engineering Center (CERDEC)**
  - Solicitation #: W15P7T-08-R-P415
- **Office of Naval Research (ONR)**
  - Solicitation #: ONRBAA 12-001, Code 31 Section 1
- **Naval Research Laboratory (NRL)**
  - Solicitation #: BAA-N00173-02, Section 55-11-02 (Mathematical Foundations of Computing)
  - Solicitation #: BAA-N00173-02, Section 55-11-03 (High Assurance Engineering and Computing)
- **Air Force Office of Scientific Research (AFOSR)**
  - Solicitation #: AFOSR-BAA-2010-1, Section c.12
- **Air Force Research Laboratory (AFRL)**
  - Solicitation #: BAA-10-09-RIKA (Cross Domain Innovative Technologies)
  - Solicitation #: BAA-11-01-RIKA (Cyber Assurance Technologies)
- **Defense Advanced Research Projects Agency (DARPA)**
  - Solicitation #: DARPA-BAA-11-63 (Automated Program Analysis for Cyber Security)
  - Solicitation #: DARPA-BAA-10-83 (Strategic Technologies Office BAA)
  - Solicitation #: DARPA-BAA-11-34 (Information Innovation Office BAA)
  - Solicitation #: DARPA-RA-11-52 (Cyber Fast Track)
  - Solicitation #: DARPA-SN-11-55 (Future Directions in Cyber Security)

Small Business Innovation Research Announcements

http://www.dodsbir.net

NSA Contact Information

(No Open BAAs)

Acquisition Resource Center
Phone: (443)-479-9572
E-mail: nsaarc@nsaarc.net

Office of Small Business Programs
Phone: (443)-479-9572
E-mail: nsaarc@nsaarc.net

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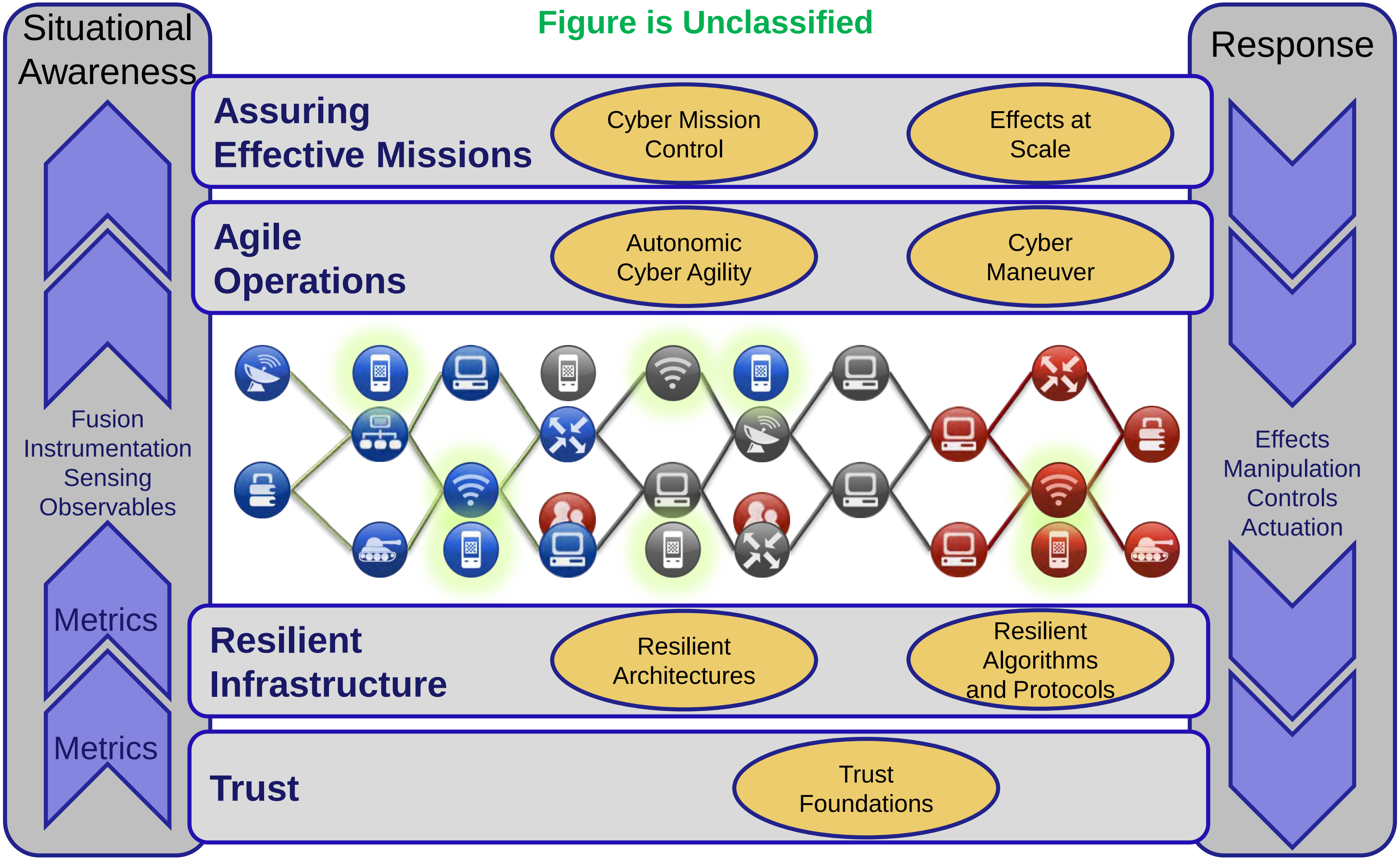
Technology Challenge Summary

POC: Dr. Steven E. King

Figure is Unclassified



Situational Awareness

Fusion
Instrumentation
Sensing
Observables

Metrics

Metrics

Assuring Effective Missions

Cyber Mission Control

Effects at Scale

Agile Operations

Autonomic Cyber Agility

Cyber Maneuver

Resilient Infrastructure

Resilient Architectures

Resilient Algorithms and Protocols

Trust

Trust Foundations

Response

Effects
Manipulation
Controls
Actuation

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